

## ABSTRACT

High voltage power supplies under high frequency pulsed loading are investigated. These are of interest for radar applications. Frequency of the pulsed load is named as pulse repetition frequency (PRF). Operating voltage for this application may be few tens of kV with average power levels of few kW to few tens of kW. This application imposes stringent performance requirements on power supplies in terms of regulation, droop, efficiency, compactness and EMI restrictions. The range of PRFs may extend from few kHz to few hundreds of kHz. Some applications may require high and variable PRF operation.

This thesis proposes three converter topologies for high PRF and variable PRF applications keeping in view the requirements of the load and design constraints. In all the proposed topologies phase-modulated series resonant converter (PM-SRC) is used as the basic power-processing unit. Achieving high order of regulation ( $< 0.005\%$ ) and stable output voltage waveform is critical in this application. Factors influencing regulation and stability of output voltage waveform are identified. Suitable measures are incorporated in the proposed topologies to improve them. Satisfying these performance specifications may require high frequency switching of the power converter. Handling of high voltage and high power at high frequency by the HV transformer is not advisable. It is due to safety and reliability of its insulation and increased losses. Evolution of proposed converter topologies is based on the need of isolating the high voltage and high power transformer from high frequency switching requirement. The required order of regulation is achieved by appropriately replenishing the charge on the output filter capacitor between the consecutive load pulses. This in turn depends on the symmetry of the current waveform charging the output filter and its frequency relative to the PRF.

First proposed topology involves single stage power conversion with PM-SRC as the power converter. Converter is switched at half of the PRF and synchronized with pulsed load. It has resulted in regulation of the order of  $< 0.001\%$  and elimination of beat frequency oscillations in the output voltage waveform. An efficiency  $> 94\%$  is achieved due to moderate switching frequency and zero voltage switching operation of the converter.

The second proposed topology is named as input voltage modulated (IVM) power converter. It involves a two-stage power conversion. One is named as base power supply (BPS)

and the other is named as fast power supply (FPS). Input voltage of BPS is modulated by the output voltage of FPS to regulate the final output voltage. Output voltage regulation is dependent on the symmetry of the current waveform produced by BPS and its frequency relative to the PRF, which charges the output filter. Switching of BPS is synchronized with the pulsed load. This topology can extend the upper limit of allowable PRF to double that is possible with single stage power conversion. Maximum regulations of  $< 0.001\%$  and  $< 0.002\%$  are achieved when the switching frequency of the BPS is  $1/2$  and  $1/4$  of the PRF respectively.

Third topology is named as output voltage modulated (OVM) power converter. It also involves two-stage power conversion. One is named as BPS and the other is named as FPS. Output voltages of both are added to form the final output voltage. The regulation achieved by this converter mainly depends on the switching frequency of the FPS and relative grading of the output filter capacitors of BPS and FPS. Under variable PRF and asynchronous operation of the converter, a regulation of  $< 0.003\%$  is achieved. For fixed PRF operation better regulation ( $< 0.001\%$ ) is achieved. This topology is suitable for PRFs as high as that for the IVM converter and also for variable PRFs.

Expressions for voltage and power ratings of FPS are derived for both IVM and OVM converter topologies. Overall efficiencies of IVM and OVM converters are mainly dependent on the efficiency of BPS. Expression for overall efficiency of both converters is derived. Overall efficiencies of  $> 92\%$  and  $> 93\%$  are achieved for IVM and OVM converter topologies respectively. All the above topologies have resulted in good regulation and stable output voltage waveforms either eliminating or minimizing the beat frequency oscillations. Simulation studies of these topologies are experimentally validated.